THE SPACE RESCUE STORY

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RE-ENTRY SYSTEMS DEPARTMENT
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Use of manned orbital operations safety equipment (Moose) to return to earth from a disabled spacecraft is shown (left to right) in sequence of drawings. The sequence begins when an astronaut puts on the plastic Moose suit and a backpack over his space suit. Outside the spacecraft, the folded heat shield is inflated. Foam fills the space between the man and the shield. Then, the astronaut

Astronaut Bail-out System Uses Foldable

By William J. Normyle

Valley Forge, Pa.–Probable first major exercise in orbit of a space rescue system would be within the confined space of a spent Saturn S-4B stage, which is developing into an all-purpose research laboratory for the National Aeronautics and Space Administration (AW&ST Sept. 5, p. 23).

Low-keyed effort in studying potential space rescue systems over the past few years is developing into one of the aerospace industry's broadest attempts at defining a difficult task (AW&ST Aug. 22, p. 11).

Space-rescue as envisioned here at General Electric Co.'s Space Technology Center concentrates on a self-help system in which astronauts carry with them into orbit the capability of returning should there be a crippling disability of their spacecraft.

Self-help system designed by GE would be carried into orbit even if the U. S. develops an earth-based rescue technique involving a redundant launch vehicle and re-entry carrier.

The possibility of developing such a necessarily expensive and perfect earth-based rescue system appears to be dim at this time.

Mueller Admission

Even Dr. George E. Mueller, associate administrator of the National Aeronautics and Space Administration for manned space flight, admits that space rescue using an earth-based system probably is not the best method.

Mueller recently said that continued emphasis on zero defects, backup flight systems and redundancies in design probably are the best method to insure successful completion of any manned orbital mission.

But there is definite interest by NASA's manned space flight officials, although not by all of them, in the kind of self-help space rescue system proposed by GE.

In tests over the past several years, GE engineers have just about completed all phases of what they can accomplish on earth for their manned orbital operations safety equipment (Moose), which in effect is a bail-out system to bring an astronaut back through the earth's atmosphere using nothing but the equipment which he carries in an emergency kit into space.

Next step would be to test the equipment in orbit, and use of the Douglas S-4B stage appears to be an ideal method, although no formal approval has been given to the proposal. Moose flight article for such a mission could be delivered one year from approval, according to GE.

Portions of the Moose structure also could be tested on earlier missions, using the three-man Apollo spacecraft to carry sections into orbit for test by an astronaut in extra-vehicular activity under thermal and zero-gravity conditions which cannot be met on the ground.

Basis of Moose is a foldable heat shield and a polyurethane foamed structure which simultaneously encapsulates, insulates and supports an astronaut during the de-orbit and re-entry processes.

The system has been patented by John H. Quillinan of the Space Technology Center's re-entry systems department. Quillinan and his superior, Harold L. Bloom, manager of advanced maneuvering re-entry return systems programs, have been working together on the Moose and its complementary phase, an Emergency Cocoon (see box, p. 75), for several years.

Sample sections of the Moose heat shield material have been flown on such vehicles as the North American X-15, and the Mk. 3 series of re-entry vehicles made by GE.

Next step, now in process, is to fabricate and test a full-scale heat shield under the most stringent thermal conditions possible. Bloom said he hopes to have an evaluation under way by the end of this year.

Heat Shield

Heat shield is an elastomeric solid material (ESM) with a maximum thickness of 0.25 in. to permit required folding.

Moose shield basically is a sphere cone 30-in. high, a 52-deg. half-cone angle and a 6-ft. base diameter with a parting flange.

ESM in tests to date has been applied to a Mylar film substructure. Difficulty of forming the ESM to a compound curve such as the shield resulted in a construction of 16 gore faces which were covered with a spackling compound and sanded to reduce angularities and provide a smooth transition from one section to the next.

stabilizes his motion and orients himself to earth with an attitude control system. He measures the direction of flight with an optical sight and fires a retro-rocket. After discarding the retro-package, he uses cold-gas jets to orient himself for re-entry. A parachute lowers the unit to the surface of the earth.

Heat Shield, Foam Structure

Mylar film 0.5 in. thick was layed up in 16 triangular gores to back up the shield itself, using a transparent tape for sealing the gores together.

Neither the film nor the tape, according to Bloom, was affected by the heat or chemicals used during the subsequent process. The ESM itself was applied with relative ease except for several problems with surface irregularities, which were smoothed by changing the curing time. Also, there was a slight crack in the shield cap, which was blamed on mishandling by personnel.

When completed, the shield was folded once, in half, and again, into quarters, and was easily packed into a box measuring 18 x 18 x 6 in.

Ablation testing of the shield material used 0.5-in.-dia. pieces of ESM bonded to elliptical aluminum discs, and the GE team still is measuring the effects. Bloom said he was confident, based on the numerous ground and flight tests, that the shielding material would perform well.

Second major portion of Moose is the foaming procedure, by which the astronaut encapsulates himself within a cocoon-like structure. Its back is represented by the heat shield.

Initial foaming process used a mixture of castor oil and a polyester prepolymer to produce a semi-rigid foam that GE engineers thought might be best from a standpoint of extracting astronauts after recovery.

Subsequently, a rigid polyurethane foam was produced that gave added support and still permitted easy extraction.

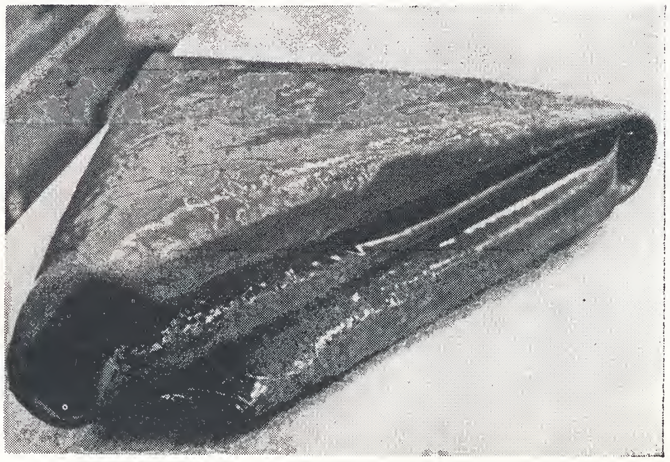
Fine uniform grain with a 2.3-lb./cu ft. density was produced by building to a maximum temperature of 260 deg. in 13 min. Total weight of the foam, poured over a dummy in a conical mold, was 100.5 lb.

Good contouring was achieved, and Bloom said support would have been adequate for re-entry and impact.

Comparisons with a human subject then were undertaken by pouring the foam over both a dummy and a man lying horizontal in a box-shaped mold. Each was suspended in the box in a sheet of 8-mil polyethylene. The man wore underwear, ventilated underwear, coveralls, socks, combat boots, sweat shirt with hood and a flight helmet. The ventilated underwear was connected to an air supply regulated at 20-30 psi.; he also had an oxygen mask.

Weight of foam poured over the dummy was 53.4 lb., at a density of 2.5 lb./cu./ft., which was found inadequate to cover the subject. The amount was increased to 73.4 lb. to cover the man, who was restrained adequately within the foam but still managed to extricate himself.

Maximum temperatures of the foam



Elastomeric solid material is applied to Mylar film substructure to form heat shield (left). Folded shield is shown at right.

on the man ranged from 90F at the neck to 149F inside the foam beneath his head.

In use, the foam would be contained in two cylinders hung from the plastic bag into which the astronaut zips himself in an emergency. Foaming is initiated outside the spacecraft.

The components are fed from their pressurized containers to a generator head which mixes them and injects the mix into the bag itself so that the bag assumes the proper re-entry shape within 1-2 min.

During the foaming process, the astronaut also uses the attitude/de-orbit package to orient the Moose to the descent and re-entry attitude.

The retro system is aligned with the attitude control using an optical sighting technique so that the astronaut can fire his tractor thrusters. The thrusters are fired manually and bent to effect re-entry.

Moose is designed to be aerodynamically stable, and recovery aids include radio signals and radar chaff for ejection at selected points. Estimates are that the total package will be landed by parachute at 20-30 fps.

The vehicle is capable of floating as a life raft, with dye markers and other location devices.

Weight of the Moose re-entry vehicle is 189 lb., including 130 lb. for the foamed structure, 15 lb. for recovery aids, 13 lb. for the parachute, 12 lb. for the survival kit, 11 lb. for life support and 8 lb. for the beacon.

Added to that is another 205 lb. for the typical suited astronaut, plus another 65 lb. for equipment in the system which is jettisoned before re-entry, such as the 50-lb. attitude/de-orbit package.

Space 'Life Raft' Under Study

Valley Forge, Pa.—Life-raft principle of space rescue is under study by General Electric Co. here for Air Force's Aeromedical Laboratory.

The system is called a cocoon and essentially provides an enclosed spherical structure in which a suited astronaut could survive in space while awaiting rescue from the ground. A test model was designed and produced by the life support engineering operation of GE's Missile and Space Div.

The full-scale laboratory model under test has a silicone rubber membrane combined into a composite wall with aluminized Mylar and a Dacron fabric. The outer 2-mil Mylar layer provides emissivity necessary to assure proper diffusion of carbon dioxide. An inner layer provides super insulation using 15-layer, 0.25-mil Mylar aluminized on one side.

A Dacron sheath, 0.0165 in. thick, carries loading pressures, and an inner, composite sandwich of 3-mil Dacron, 1.5-mil silicone rubber and 3-mil Dacron protects a membrane which provides water vapor and carbon dioxide control.

The cocoon is almost completely passive, requiring only the oxygen supply and batteries for thermal control.

Theory of the cocoon is that by a process of absorption and diffusion, the materials which compose the shell permit gases to leak into space at varying rates.

The silicone rubber film allows the carbon dioxide exhaled by the astronnaut, and the water vapors generated by him, to be diffused into space at a faster rate than the oxygen consumed. The system thus eliminates the need for atmospheric control equipment.

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